Advanced Space Suit Project (formerly Extravehicular Activity Suit/Portable Life Support System)

Advanced Exploration Systems Program | Human Exploration And Operations Mission Directorate (HEOMD)

ABSTRACT

The primary objective of the Advanced Space Suit project is to develop EVA Systems technology to enhance and enable efficient human exploration missions to any destination. The project is focused on technologies for a new advanced Portable Life Support System (PLSS), Power and Avionics Systems, and Pressure Garment Systems (PGS) to support human exploration to asteroids, the Moon, and planetary bodies such as Mars and its moons. The challenges of working in these exploration environments exceed those of the current ISS system and will require that all new technologies be more robust, tolerant of dusty environments, work in both vacuum and non-vacuum environments, and support increased crew autonomy.

ANTICIPATED BENEFITS

To NASA funded missions:

Increased EVA time, reduced consumables, decreased crew time for maintenance and checkout, EVA capability in multiple environments and destinations

To NASA unfunded & planned missions:

Enable EVA capability in Mars gravity and atmosphere, in high radiation environments, and for 100+ EVA mission architectures

To the commercial space industry:

Reducing risk for novel and lightweight materials and systems for human-rated applications.

To the nation:

Supporting sustainable long-term human space exploration.

DETAILED DESCRIPTION

The objective of this project is to mature technologies and systems that will enable future Extravehicular Activity (EVA)

Suit Engineering demonstrating the impressive mobility of the Z-1 prototype.

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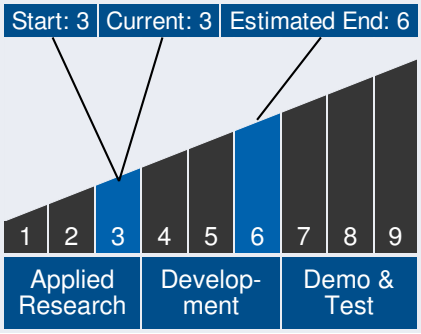
systems. Advanced EVA systems have applicability to all future human spaceflight missions. Advanced EVA systems have applications to current operations on the International Space Station (ISS), to extended operations on ISS past 2020, future missions to Low Earth Orbit (LEO) such as satellite servicing, missions beyond LEO such as exploration of asteroids, and surface exploration missions to the Moon or Mars. An EVA system would be a significant element of any future human exploration mission and will enable suitport operations in a Deep Space Habitat or Multi-Mission Space Exploration Vehicle (MMSEV). The Human Exploration Framework Team (HEFT) ranked EVA systems as one of the top five needed areas of future development for human space flight. The project's goal is to produce real cost, performance, and reliability data through building and testing high fidelity systems, culminating in a flight demonstration on ISS of an exploration Extravehicular Mobility Unit (EMU). The current plan leading to this flight demonstration consists of subsystem demonstrations of increasing fidelity. These demonstrations would produce hardware and systems that could then be combined into a complete EVA system which would be used in human thermal-vacuum chamber tests and finally in a flight demonstration.

Technology Maturity



1 Success Story

Management Team

Program Director:
- Jason Crusan

Program Executive:
- Barry Epstein

Project Managers:
- Lindsay Aitchison
- Liana Rodriggs

Principal Investigator:
- Liana Rodriggs

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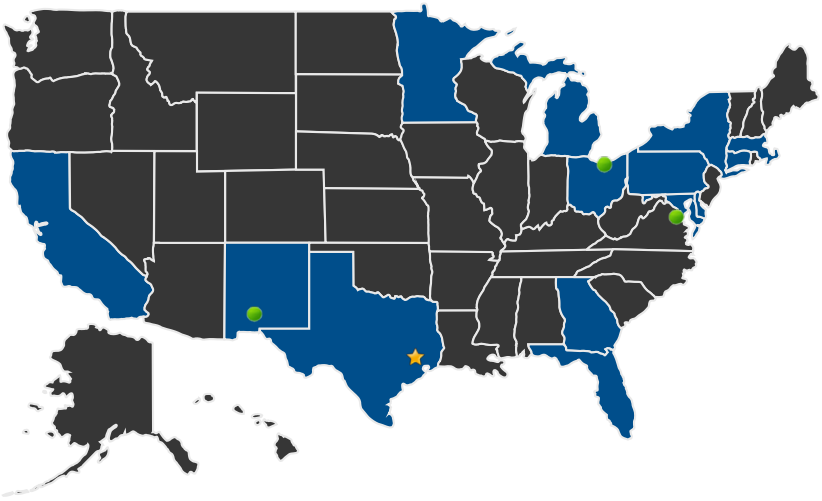
U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Johnson Space Center

Supporting Centers:

- Glenn Research Center
- NASA Headquarters
- White Sands Test Facility

Technology Areas

Primary Technology Area:
Human Health, Life Support, and Habitation Systems (TA 6)

- Extravehicular Activity Systems (TA 6.2)
  - Portable Life Support System (TA 6.2.2)
    - Closed-Loop Heat Rejection System with Zero Consumables; Spacesuit Water Membrane Evaporator (SWME)-Radiator Hybrid (TA 6.2.2.1)
    - Alternate Contaminant Control Cartridge (CCC) Sorbent (TA 6.2.2.10)
    - CO2 and H2O Membrane (TA 6.2.2.11)

Continued on following page.

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Other Organizations Performing Work:

- Air-Lock, Inc. (Milford, CT)
- Cobham
- David Clark Company, Inc.
- First-Cut
- Georgia Institute of Technology
- Hamilton Sundstrand
- Harris Engineering (Richmond, TX)
- ILC Dover
- Jacobs Engineering
- Oceaneering International Inc. (Houston, TX)
- Philadelphia University
- Physical Optics Corporation (Torrance, CA)
- Pratt & Miller Engineering
- Turn-Key Coatings
- University of Delaware Center for Composite Materials (Newark, DE)
- University of Minnesota (Minneapolis, MN)
- UTC Aerospace Systems
- Vista Photonics
- Wolverine
- Wyle Laboratories
- Xigen, LLC (Rockville, MD)

LATEST SUCCESS STORY

Success Story AES Advanced Space Suit PLSS 2015-08-28

Success Story AES Advanced Space Suit PLSS 2015-08-28

PROJECT LIBRARY

Success Stories

- Success Story AES Advanced Space Suit PLSS 2015-08-28
  - (http://techport.nasa.gov:80/file/17664)

Technology Areas *(cont.)*

Additional Technology Areas:

Human Health, Life Support, and Habitation Systems (TA 6)
- Extravehicular Activity Systems (TA 6.2)
  - Portable Life Support System (TA 6.2.2)
    - Closed-Loop Heat Rejection System with Zero Consumables; Heat Pump Radiator Hybrid (TA 6.2.2.2)
    - Closed-Loop Heat Rejection System with Zero Consumables; Portable Life Support System (PLSS) Radiator (TA 6.2.2.3)
    - Portable Life Support System (PLSS) Fan (TA 6.2.2.4)
    - Portable Life Support System (PLSS) Pressure Sensor (TA 6.2.2.5)
    - Closed-Loop On-Back Regenerable CO2 and Humidity Control (TA 6.2.2.6)
    - Closed-Loop Consumable CO2 Removal, Low Mass (TA 6.2.2.7)
    - Alternate CO2 Sorbent (TA 6.2.2.8)
    - Atmospheric Constituent Sensor (TA 6.2.2.9)

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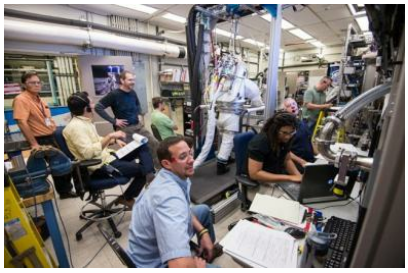
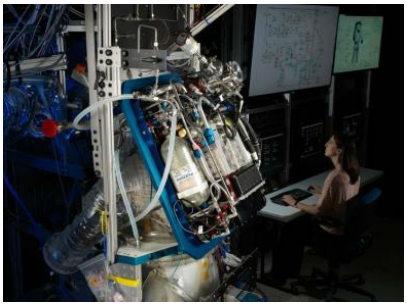
IMAGE GALLERY



Human-in-the-loop testing of the PLSS 2.0 system with the MK-III space suit prototype-1

Human-in-the-loop testing of the PLSS 2.0 system with the MK-III space suit prototype-2



Project Engineer conducting system checkouts of the Suited Manikin Test Apparatus.

Z-1 suitport interfaces testing with the MMSEV prototype vehicle.

Z-2 Advanced Prototype Pressure Garment in Donning Stand

Z1 suit in its donning stand.

DETAILS FOR TECHNOLOGY 1

Technology Title

Advanced Space Suit (formerly Extravehicular Activity (EVA) Suit/Portable Life Support System (PLSS))

Technology Description

This technology is categorized as a hardware system for wearable applications

The objective of this project is to mature technologies and systems that will enable future Extravehicular Activity (EVA) systems. Advanced EVA systems have applicability to all future human spaceflight missions. Advanced EVA systems have applications to current operations on the International Space Station (ISS), to extended operations on ISS past 2020, future missions to Low Earth Orbit (LEO) such as satellite servicing, missions beyond LEO such as exploration of asteroids, and surface exploration missions to the Moon or Mars. The Human Exploration Framework Team (HEFT) ranked EVA systems as one of the top five needed areas of future development for human space flight. The goal is to produce real cost, performance, and reliability data through building and testing high fidelity systems, culminating in a flight demonstration on ISS of an exploration EMU. The current plan leading to this flight demonstration consists of subsystem demonstrations of increasing fidelity. These demonstrations would produce hardware and systems that could then be combined into a complete EVA system which would be used in human thermal-vacuum chamber tests and finally in a flight demonstration.

Capabilities Provided

Suitport-compatible Advanced Extravehicular Mobility Unit (EMU) that enables EVA capability for any environment and mission architecture, with increased reliability, robustness, cycle life, comfort, and mobility; and reduced weight, power, and consumables usage.

Potential Applications

Advanced EVA systems have applicability to all future human spaceflight missions. There are several components of the Advanced EVA Systems PLSS that could be considered for near-term integration into the existing EMU PLSS to support ISS operations through 2028, including the CO2 sensor development and the Suit Water Membrane Evaporator (SWME). Additionally, the basic technology of the Rapid Cycle Amine (RCA) unit being designed for CO2 scrubbing in the suit ventilation loop is also being considered for inclusion in the Orion space craft. As we move toward exploration, the entire PLSS is being designed as a standalone system that can be mounted to any variety of suits, via specialized kits, to support free roaming EVAs for locations such as asteroids,

the Moon, or Mars. The Z-series pressure garments are primarily geared toward planetary exploration, meaning they include walking mobility and new technologies to enable robust operations in non-pristine environments, but unique features such as lock-outs in bearings and low torque thermal, micrometeoroid garments (TMGs) will make the Z-series suits capable of efficient operations in microgravity missions as well--including asteroid exploration, deep space vehicle servicing, and the moons of Mars. Some components of the PGS, such as gloves or hard upper torsos, could also be used to upgrade the current ISS EMU pressure garment.

Performance Metrics

Metric	Unit	Quantity
High Data Rate Data Transmission	Mbps	10.36
High Energy Density Battery	Watt-hour/liter	705
High Pressure Oxygen Recharge in a Dusty Environment	cycles	200
High Specific Energy Battery	Watt-hour/kg	235
Integrated Audio Speech Quality and Intelligibility	percent word identification	95
Lightweight Bearings	kg	5.5
Long Duration Gloves	hours	800
Long Duration System Operation	hours	800
Regenerable Carbon Dioxide Removal	kg	3.4
System Weight	kg	136
Variable Pressure Regulator	settings	400